Laser induced periodic surface processing of silicon

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Morphological modifications of the surface of a solid material can substantially alter its properties. Nowadays, direct femtosecond (fs) laser micromachining has been demonstrated as a versatile and effective surface modification technique thanks to some evident advantages, e.g. capability of modifying any material under different ambient conditions, avoiding clean room or high vacuum equipment, as well as its capacity to generate a large variety of hierarchical micro- and nano-structures. Among others, laser induced periodic surface structures (LIPSS) constitute particularly relevant and interesting structures which are still under intensive investigation [1].

Here we report on the effect of the target scanning velocity on LIPSS formed on an intrinsic silicon (100) crystal, in air. The laser pulses are provided by a Yb:KGW laser source (~ 1030 nm, ~ 180 fs) operating at a repetition rate of $f_p = 1\ kHz$. The laser beam is focused on the target surface by a plano-convex lens (nominal focal length of 200 mm) at normal incidence. Target irradiation was carried out in two different modes: shallow craters were produced by a sequence of *N* laser pulses keeping the target standing (static configuration), whereas lines were generated continuously translating the target at a fixed velocity V_s (dynamic configuration). In this last case, the effective pulse number is $N_{eff} = 2w_0 \frac{f_p}{V_s}$,, where w_0 is the laser spot size at $1/e^2$ of the maximum intensity for a beam with a Gaussian spatial profile. The morphological features of the produced LIPSS (ripples and grooves), carried out by means of a field emission scanning electron microscope (FE-SEM – Zeiss Σigma), are analyzed to gain information on their formation threshold and incubation effects. Moreover, two-dimensional Fast Fourier Transform (2D-FFT) of the SEM image are used to address LIPSS regularity issues at similar total fluence dose achieved by different parameters of the laser pulse sequence.

[1] Bonse, J.; Gräf, S., *Ten Open Questions about Laser-Induced Periodic Surface Structures*, Nanomaterials 11, 3326 (2021).

[2] JJ Nivas, J.; Amoruso, S., *Generation of Supra-Wavelength Grooves in Femtosecond Laser Surface Structuring of Silicon*, Nanomaterials 11 (2021) 174.